

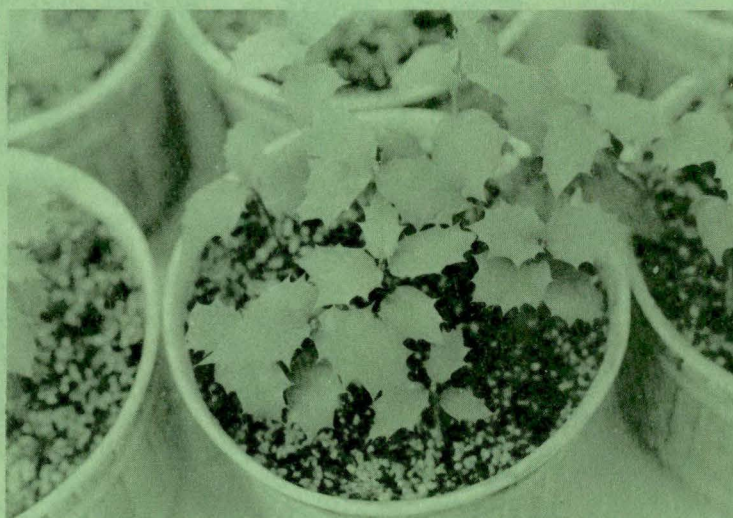
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CHAPARRAL CONTROL PROJECT

ANNUAL REPORT - 1958

by

E. A. Davis



UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Research Service
Crops Research Division
Crops Protection Branch

Rocky Mountain Forest and Range Experiment Station
Arizona State University
Tempe, Arizona

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SUMMARY

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A laboratory and greenhouse program was initiated in March 1958 to develop methods for the chemical control of Arizona chaparral species -- emphasis being placed on Quercus turbinella. Before starting laboratory studies it was necessary to obtain plant material. Being without acorns, an attempt was made to root cuttings and sprouts. After a series of unsuccessful attempts, cuttings were finally rooted using intermittent or constant mist and high light intensity. Large sprouts attached to crown wood or underground stem pieces were also rooted by keeping them in a humid atmosphere. However, establishment required approximately six months. More work is needed to make the methods practical.

In August, acorns were collected and plantings were established for herbicide investigations. Quercus turbinella acorns have no dormancy and are capable of germinating when they drop. If allowed to dry out they lose germinability. Under conditions of moist cold storage they germinated after 14, 34, and 54 days at 50°, 40°, and 35°F respectively. Germination was most rapid at 80°F.

Herbicide evaluation studies in the laboratory are now in progress.

INTRODUCTION

A research program for the chemical control of Arizona chaparral was initiated in 1958 by the Agricultural Research Service of the U. S. Department of Agriculture in cooperation with the U. S. Forest Service. This research is being conducted by the Crops Protection Branch of the Crops Research Division. The chemical control of chaparral vegetation is one facet of the Arizona watershed management program of the Forest Service to determine the influence of vegetation manipulation on water yield. It is also closely related to range management research involving the conversion of brushland to grassland. The overall objective is to develop practical chemical methods for controlling chaparral species, placing emphasis on both practical and fundamental aspects which may have a bearing on woody-plant control in general.

This work is being conducted at the Rocky Mountain Forest and Range Experiment Station on the campus of Arizona State University in Tempe, Arizona. Space and facilities during most of 1958 were generously made available by the University. New research facilities of the Forest Service including offices, a laboratory and three attached greenhouses (15' x 20') (Fig. 1) were occupied in November. Furnishing of the laboratory is not yet complete. The greenhouses are equipped with heaters and evaporative coolers.



Figure 1.--Views of the new research facilities of the Rocky Mountain Forest and Range Experiment Station located on the campus of Arizona State University, Tempe, Arizona.

GENERAL INFORMATION

Some of the major shrubs which compose the chaparral type in Arizona are: turbinella oak (Quercus turbinella), desert ceanothus (Ceanothus Greggii), hollyleaf buckthorn (Rhamnus crocea), skunkbush sumac (Rhus trilobata), mountain mahogany (Cercocarpus montanus), manzanita (Arctostaphylos pungens), and Wright silktassel (Carrya Wrightii). In the chaparral of central Arizona, turbinella oak is generally the most abundant shrub, often accounting for 60 to 90 percent of the cover and is one of the least desirable shrubs from the grazing aspect. It cannot be eliminated permanently by fire because of its ability to sprout (Fig. 2); stands which develop following fires frequently are denser than original stands. Mechanical removal with the root plow shows considerable promise but the method is of limited value in Arizona because of the steep and rough nature of much of the chaparral terrain. Early work conducted by the University of Arizona and the U. S. Department of Agriculture with growth regulator sprays demonstrated that turbinella oak was the shrub to concentrate on in future chemical control studies. But to the present time foliar sprays with herbicides have been only moderately successful. For these reasons emphasis has been placed on turbinella oak in the work to be reported. It is intended that subsequent studies will be broadened to include other chaparral species.

A detailed outline of this project entitled, "Laboratory and Greenhouse Research Program on the Chemical Control of Chaparral in Arizona", was submitted in June 1958, and the reader is referred to it for the overall research plan. Work during the past year involved two aspects of the program -- plant material and herbicide evaluation. A great deal more difficulty was encountered in obtaining turbinella oak plants for greenhouse experiments than was anticipated, necessitating considerable time in finding suitable



Figure 2.--Sprouting of turbinella oak crowns following fire. The bottom picture shows a mass of sprouts which had not reached the soil surface.

propagation methods. When the program started in March, acorns were not available, and learning that a yearly supply was not dependable, efforts were made to root cuttings and sprouts. Lacking elaborate facilities, simple methods were tried first -- making improvements as necessary, depending upon results.

The acorn crop in 1958 was poor but through much searching a sizeable collection was made during August and September. Because adequate space for growing large numbers of plants at once was not available at this time, the storage of the acorns became a problem. Information concerning the storage of turbinella oak acorns was lacking but recommendations of moist cold storage for the closely related Quercus dumosa of California were adopted as much as possible. Concomitantly, studies were made to determine the storage requirements of turbinella oak; and some of the factors influencing acorn germination were investigated.

It was soon found that turbinella oak seedlings grow slowly and in order to hasten growth by providing as near optimum conditions as possible, studies were undertaken to determine these conditions.

Turbinella oak seedlings suitable for herbicide evaluation tests in the greenhouse were ready by the latter part of December, and an experiment with a group of pelleted and granular herbicides for soil applications was established.

Research work plans for a cooperative field experiment with Dr. D. T. Lillie (ARS) on the influence of leaching on the effectiveness of several pellet and granular herbicides applied to the soil were formalized in December. The chemicals in this test will be applied early in 1959.

Anticipating laboratory and greenhouse studies with chaparral species other than turbinella oak, a collection was made of mountain mahogany seed in November.

Having dealt with the past year's program in very broad terms the results of specific investigations will follow. Most of the work was exploratory in nature.

PROPAGATION OF TURBINELLA OAK FROM CUTTINGS AND SPROUTS

Introductory Statement

A series of attempts were made to propagate turbinella oak. Because of the lack of propagation facilities at the outset of this work, very simple methods were tried first in the event they might suffice. Elaborations were made as dictated by failures.

Propagation of Turbinella Oak 1. Cuttings, Sprouts, and Underground Stems Under Uncontrolled Greenhouse Conditions. (Expt. 1-1-1)

1. Objectives:

- A. To propagate turbinella oak vegetatively.
- B. To determine the most suitable material for propagation.

2. Materials and Methods:

A. Plant material:

Sprouts, underground stems, and cuttings from sprouts were obtained in an area which had burned two years previously. Sprout regrowth was 1-2 feet tall. The plants were still inactive; spring growth had not yet started.

B. Collection Location: Mingus Mountain, Dewey, Arizona

C. Collection Date: March 6, 1958

D. Collection Procedure:

Terminal cuttings were taken from sprouts. Underground stems and sprouts with underground stems were dug from around old stumps. The bottoms of the cuttings were covered with moist soil.

E. Types of Cuttings and Treatments:

Plant Material	Age (Years)	Treatment	Number Per Treatment
Terminal softwood with leaves	1	None	30
		Quick-Root powder	30
		Kept in dist. water	6
Small leafy sprouts with under-ground stem pieces	1-2	None	20
		Quick-Root powder	20
Underground stem pieces	-	None	50
Clump of sprouts with under-ground burl	2	None	2
Large sprouts with under-ground stem pieces	3-4	None	5

Total number of propagules = 163

F. Propagation Facility:

Unheated greenhouse. The cuttings and sprouts were planted in soil contained in pots.

G. Date Treated and Planted: March 7, 1958.

H. Environmental Conditions:

Night and morning temperatures, 50°-60°F; maximum afternoon temperature, 90°F; relative humidity, 5-21%. Tap water was used for watering.

I. Date of Final Observations: June 9, 1958

J. Duration of Experiment: 90 days

3. Results and Conclusions:

None of the cuttings, sprouts, or underground stem pieces survived.

One sprout with underground stem piece which was treated with Quick-Root powder formed a root but the root decayed; additional roots were not initiated and the sprout died. The leaves of the cuttings and sprouts withered and died. In order to propagate turbinella oak vegetatively more ideal conditions are required.

Propagation of Turbinella Oak 2. Cuttings in an Outside Propagation Bed.

(Expt. 1-1-2)

1. Objective: To root turbinella oak cuttings.

2. Materials and Methods:

A. Plant Material:

Softwood cuttings were taken from sprouts in a burned area. Hardwood cuttings were taken from large shrubs. Spring growth had not started.

B. Collection Location: Dewey, Arizona

C. Collection Date: April 2, 1958

D. Collection Procedure:

Cuttings were taken and placed immediately in water. They were then sprayed with water and wrapped in wet burlap.

E. Storage Prior to Planting:

The cuttings were stored moist for six days at 40°F prior to planting. They were in good condition when planted.

F. Types of Cuttings and Treatments:

Cutting Material	Age (Years)	No. of Cuttings Per Treatment	Treatments % IBA Solution (15 sec. dip)
Terminal softwood with leaves	1	80	0, 0.05, 0.1, 0.5, 1.0
Basal softwood without leaves	1	42	"
Hardwood with leaves	2-3	18	"
Hardwood with leaves	4-5	7	"

A basal strip of bark was removed from half of the cuttings for each treatment. Total number of cuttings = 735. All but a few leaves were removed from those cuttings on which leaves were left.

G. Propagation Facility:

An outside propagation bed was used containing flats of coarse crystal white sand. The bottom of the flats were made of galvanized wire screening to facilitate the drainage of water. An air space below the flats contained a heating coil to provide the cuttings with bottom heat. The bed was covered with window sash. This unit was the property of Arizona State University and was used for rooting a variety of cuttings.

H. Date Treated and Planted: April 8, 1958

I. Environmental Conditions:

Day temperature in propagation bed, 80°-93°F; sand temperature, 75°-80°F, relative humidity, ca. 50%. Tap water was used for watering.

J. Date of Final Observations: June 10, 1958

K. Duration of Experiment: 63 days

3. Results and Conclusions:

The leaves of the cuttings withered and died. But in many cases buds expanded and new leaves developed. None of the cuttings rooted; however, and they all eventually died. Basal stem rot was general. Under the same conditions cuttings of grape, texas ranger (Leucophyllum texanum), mulberry, and poinsettia rooted.

It is apparent that the requirements for rooting turbinella oak cuttings are more stringent than those for many cuttings.

Propagation of Turbinella Oak 3. Cuttings in a Commercial Propagation House. (Expt. 1-1-3)

1. Objective: To root turbinella oak cuttings.

2. Materials and Methods:

A. Plant Material:

Softwood cuttings were taken from sprouts in a burned area. Spring growth had just started; new leaves were present. Hardwood cuttings were taken from large shrubs.

B. Collection Location: Dewey, Arizona

C. Collection Date: April 25, 1958

D. Collection Procedure:

Cuttings were taken and placed immediately in water. They were then sprayed with water and wrapped in wet burlap.

E. Storage Prior to Planting:

The cuttings were held for five days at 40°F under moist conditions prior to planting. They did not appear to be injured by this treatment and looked in good condition when planted.

F. Treatments:

Method	Treatment	Chemical Conc (%)
24 hr. soak	Dist. water	-
	3-Indolebutyric acid (IBA)	.01
	α -Naphthaleneacetic acid (NAA)	.01
	3-Indoleacetic acid (IAA)	.01
15 sec. dip	50% Acetone solvent check	-
	IBA	1.0
	NAA	1.0

A basal strip of bark was removed from half of the cuttings for each treatment.

G. Types of Cuttings:

Cutting Material	Age (Years)	No. of Cuttings Per Treatment
Terminal softwood with leaves	1	20
Basal softwood without leaves	1	20
Hardwood with leaves	2	10
Hardwood with leaves	3-4	4
Malet hardwood with leaves	3-4	4

Total number of cuttings: 406.

All but a few leaves were removed from those cuttings on which leaves were left.

H. Propagation Facility:

A commercial nursery's propagation house was used. It was equipped with an evaporative cooler which operated during the day. The propagation flats contained coarse crystal white sand. The bottoms of the flats were made of galvanized wire screening to facilitate the drainage of water. An air space below the flats contained a thermostatically regulated heating coil to provide the cuttings with bottom heat.

I. Date Treated and Planted: May 2, 1958

J. Environmental Conditions:

Sand temperature, 74°-80°F; air temperature, 75°-87°F; relative humidity, ca. 50%. Tap water was used for watering.

K. Date of Final Observations: June 11, 1958

L. Duration of Experiment: 40 days

3. Results and Conclusions:

The leaves of the cuttings became desiccated and died. In many instances buds expanded and new leaves developed but they subsequently withered. None of the cuttings rooted. Basal stem rot was common.

The facilities were adequate for rooting a wide variety of cuttings. However, the conditions were inadequate for turbinella oak. Higher humidity conditions and the prevention of stem rot are improvements which might make rooting possible.

Propagation of Turbinella Oak 4. Young Sprouts and Underground Stems in
an Outside Propagation Bed. (Expt. 1-1-4)

1. Background:

Terminal softwood and hardwood cuttings failed to root in the outside propagation bed but young sprouts with underground stems and underground stem pieces had not been tried. The appearance of this type of material suggests that it should root rather readily. By taking the extra precaution of covering the flats with plastic film it was thought that the method might be successful.

2. Objective:

To root turbinella oak sprouts and underground stems.

3. Materials and Methods:

A. Plant Material:

Young sprouts with underground stems originating from old crowns were collected in a burned area. The sprouts were 3-4 inches long and consisted of an underground stem and a shoot which may or may not have reached the soil surface. Underground stems were obtained by clipping the proximal ends. The latter material had no leaves or roots but had numerous buds. The sprouts were succulent and actively growing.

B. Collection Location: Dewey, Arizona

C. Collection Date: April 25, 1958

D. Collection Procedure:

The sprouts were dug from around old stumps. Obtaining good material was rather difficult and also time consuming. The sprouts and underground stems were placed in water immediately after they were dug; they were then wrapped in wet burlap.

E. Storage Prior to Planting:

The sprouts and underground stems were stored moist at 40°F for 6 days before they were planted.

F. Treatments for Sprouts and Underground Stems:

Treatment	Conc. (%)	
	15 sec. dip	24 hr. soak
3-Indolebutyric acid	1	.01
α -Naphthaleneacetic acid	1	.01
Solvent Check (Acetone)	50	-
Water Check (24 hr. soak)	-	-
Untreated Control	-	-

Ten sprouts and 6 underground stem pieces for each treatment.

Eight sprouts untreated. Total number of sprouts: 104.

G. Propagation Facility:

Outside propagation bed described in Expt. 1-1-2. To prevent the sprouts from drying, the flats were covered with plastic film. The underground stem pieces were planted in a horizontal position beneath the sand.

H. Date Treated and Planted: May 1, 1958

I. Environmental Conditions:

Day temperature, 80°-90°F; humidity under the plastic film, relatively high.

J. Date of Final Observations: June 10, 1958

K. Duration of Experiment: 38 days

4. Results and Conclusions:

None of the sprouts or underground stem pieces survived. Rooting did not occur except on a single control sprout, and in that case the root decayed. Disease was the major cause of loss in the cutting bed.

Turbinella oak appears to be very susceptible to stem and root rot.

It is clear that these diseases will have to be eliminated or reduced if turbinella oak is to be rooted successfully.

Propagation of Turbinella Oak 5. Cuttings, Sprouts, and Underground Stems
Under Intermittent Mist and Weak Light in a Laboratory Propagation Chamber.
(Expt. 1-1-5)

1. Background:

In previous attempts to root turbinella oak the loss of cutting material could be attributed chiefly to disease and leaf desiccation. The need for a propagation system which would provide high humidity conditions was considered necessary. In view of the failures experienced with existing facilities and mounting outside temperatures it was decided to build a propagation chamber in the air-conditioned laboratory of the Agricultural Building. This experiment utilizes such a chamber. In addition, the time between taking the cuttings and planting was shortened as much as possible in order to reduce loss of cutting vitality to a minimum.

2. Objective:

To propagate turbinella oak by means of cuttings, sprouts, or underground stem pieces.

3. Materials and Methods:

A. Plant Material:

Terminal softwood cuttings from sprouts, young sprouts with underground stems, and underground stem pieces, were collected in a burned area. The sprouts were actively growing and had young succulent growth. These propagules were obtained in the manner described in previous experiments.

B. Collection Location: Dewey, Arizona

C. Collection Date: June 5, 1958

D. Collection Procedure:

The cuttings, etc., were placed in water immediately after they were cut. They were then sprayed and placed in plastic bags which were in turn stored in an insulated plastic bag cooled with ice. The time between taking the cuttings and planting was kept as short as possible in order to maintain the vitality of the cuttings. The collection area was 100 miles from Tempe; six hours elapsed between the time the first cutting was taken and the last one was planted

E. Treatment of Cuttings:

The cuttings and sprouts were trimmed, removing all but two or three terminal leaves and planted without chemical treatment; 138 pieces were planted including underground stem pieces.

F. Propagation Chamber:

The propagation unit consisted of a polyethylene film chamber containing two flats with wire screen bottoms. A deVilbiss suction type atomizer projected through one end of the chamber. An extension of the fluid inlet tube of the atomizer feed into a bottle of distilled water while the air inlet was connected to a compressed air line through a solenoid valve which was activated by a can recycling timer for intermittent mist operation. Drainage water was collected in trays beneath the flats. This unit was located on a laboratory bench.

G. Rooting Media:

Because cuttings frequently root better in some media than in others the following media were tested: coarse crystal white sand, Sponge-Rok, vermiculite, peat, a 50-50 mixture of peat and sand, and a 50-50 mixture of vermiculite and sand.

H. Date Planted: June 5, 1958

I. Environmental Conditions:

Intermittent mist, started at 25% of each minute and was reduced to 6.25%; relative humidity, 97%; temperature of medium and in chamber, 72°-77°F; light intensity, 53 f.c.

J. Date of Final Observations: June 24, 1958

K. Duration of Experiment: 19 days

4. Results and Conclusions:

None of the cutting material rooted or survived. The entire cuttings underwent general necrosis, becoming water-soaked and decayed. This is attributed to the high moisture condition in the chamber in combination with the low light intensity. Loss of cutting vitality during an extended storage period cannot account for the rapid decline of the cuttings since they were planted within six hours after being taken. Under high moisture conditions cutting survival may be improved by increasing the light intensity.

Propagation of Turbinella Oak 6. Cuttings and Sprouts Under Intermittent
Mist and Saturating Incandescent Light in a Laboratory Propagation Chamber.
(Expt. 1-1-6)

1. Background:

High humidity and intermittent mist in combination with weak light was inadequate for maintaining and rooting turbinella oak cuttings, suggesting the need for stronger illumination. This experiment provides intermittent mist and saturating incandescent light.

2. Objective:

To root turbinella oak cuttings and sprouts.

3. Materials and Methods:

A. Plant Material:

Terminal softwood cuttings of sprouts and sprouts with underground stem pieces were collected in a burned area. The sprouts were actively growing and contained young succulent leaves.

B. Collection Location: Dewey, Arizona

C. Collection Date: July 1, 1958

D. Collection Procedure:

The stems of the cuttings were placed in water immediately after they were taken. They were then placed in plastic bags and stored in a portable cooler. The cuttings were planted as soon as possible after they were collected. A maximum of seven hours elapsed between the time the first cutting was taken and the last one was planted.

E. Treatment of Cuttings:

Hormone treatments consisted of Rootone and Transplantone (commercial root initiation and root stimulant powder preparation). Rootone contains a mixture of growth regulators including naphthylacetamide and 3-indolebutyric acid; it also contains the fungicide Thiram. Transplantone contains naphthylacetamide and vitamin B-1. Most of the leaves were left on the cuttings. Only enough were removed to facilitate planting.

F. Propagation Chamber:

The propagation chamber was similar to that previously described, with the addition of a bank of 4, 300-W incandescent lamps over the chamber. Operation of the lamps was controlled by a time clock. Some of the infrared rays were removed by a filter consisting of an inch of flowing water in a plexiglass tray on top of the chamber.

G. Rooting Media:

Six media were tested. Cf. table 1.

H. Date Planted: July 1, 1958

I. Environmental Conditions:

The intermittency of the mist was regulated in order to keep the cuttings just moist, avoiding excess moisture. During most of the experiment the mist operated 2.5% of a 15 minute cycle. Distilled water mist, 13 days; nutrient solution mist, 42 days. Relative humidity, 81-88% (average range); temperature in chamber, day, 85°-88°F, night minimum 72°F; light intensity at level of cuttings, 1,500-1,700 f.c.; day length, 14 hrs.

J. Date of Final Observations: August 25, 1958

K. Duration of Experiment: 55 days

4. Results and Conclusions:

- A. Turbinella oak cuttings and sprouts were successfully rooted. The highest percentage rooting obtained was 33% with sprouts, with or without hormone treatment, and 20% with cuttings using Rootone (Table
- B. Successful rooting is attributed to intermittent mist and high light intensity.
- C. Treatment of the cuttings with Rootone did not significantly improve rooting. Transplantone powder was toxic and killed most of the cuttings. The reason for this is not known.
- D. Slightly superior rooting results were obtained with sprouts having underground stem pieces than with terminal cuttings.
- E. The media which resulted in the best rooting were Sponge-Rok, sand, and a 50-50 mixture of peat and sand.
- F. Stem rot was very prevalent and resulted in heavy losses of cuttings and sprouts.
- G. It was demonstrated that turbinella oak cuttings can be rooted. If cutting loss due to disease could be reduced it is possible that a higher percentage of rooting would result.

Table 1.--Rooting results of turbinella oak cuttings and sprouts under intermittent mist and saturating incandescent light in a laboratory propagation chamber (Expt. 1-1-6).

Cutting Material	Propagation Medium	Untreated Control				Rootone				Transplantone				Av. % Rooting (Omitting Transplantone)
		A	H	C	R	A	H	C	R	A	H	C	R	
		Percent				Percent				Percent				
Softwood Sprout Terminal Cuttings	Vermiculite	50	30	30	10	0	0	0	0	10	0	0	0	5
	Sponge-Rok	60	20	10	10	20	20	20	20	0	0	0	0	15
	Sand	50	30	30	0	90	10	30	10	10	0	0	10	5
	Peat	0	0	0	0	0	0	0	0	0	0	0	0	0
	Peat & Sand	0	0	0	0	60	20	20	20	0	0	0	0	10
	Vermic. & Sand	0	0	0	0	20	10	10	0	0	0	0	0	0
	Average	27	13	12	3	32	10	13	8	3	0	0	2	6
Sprouts with Underground Stem Pieces	Vermiculite	100	0	0	0	33	17	0	0	17	0	0	0	0
	Sponge-Rok	83	33	33	33	83	33	17	17	0	0	0	0	25
	Sand	100	67	50	0	100	67	33	33	17	0	0	0	16
	Peat	50	17	17	0	33	0	0	0	0	0	0	0	0
	Peat & Sand	66	17	0	17	0	0	0	0	0	0	0	0	8
	Vermic. & Sand	66	33	0	17	33	33	17	0	0	0	0	0	8
	Average	78	28	17	11	47	25	11	8	6	0	0	0	10
Overall Average		52	20	14	7	40	9	12	8	4	0	0	1	8

Abbreviations: A = Alive, H = Healthy, C = Callused, R = Rooted.

There were 10 cuttings and 6 sprouts per treatment.

Total number of cuttings and sprouts: 288.

Propagation of Turbinella Oak 7. Cuttings Under Intermittent Mist and
Saturating Incandescent Light in a Laboratory Propagation Chamber Using
Sanitary Procedures. (Expt. 1-1-12)

1. Background:

Turbinella oak was successfully rooted using an intermittent mist, high light intensity system (Expt. 1-1-6). However, cutting loss due to disease was heavy. In this experiment sanitary precautions were adopted in the hope of obtaining increased rooting.

2. Objective:

To root turbinella oak cuttings.

3. Materials and Methods:

A. Plant Material:

Terminal softwood cuttings were collected from actively growing sprouts in a burned area.

B. Collection Location: Dewey, Arizona

C. Collection Date: September 16, 1958

D. Collection Procedure:

Same as previously described except that the cuttings were wrapped in clean wet muslin rather than in plastic bags. By keeping the muslin wet, the cuttings remained moist and cool. The cuttings were planted the same day with the exception of those which received chemical soak treatments.

E. Sanitary Procedures:

1. The propagation flats were treated with copper naphthenate.
2. Treated flats filled with propagation media were autoclaved for 30 minutes at 15 lbs. pressure.
3. The chamber was washed with sodium hypochlorite solution.
4. The trays for collecting drainage water were cleaned and painted with copper naphthenate.
5. All of the cuttings received a stem dip in 0.5% sodium hypochlorite solution for 15 seconds. Preliminary tests showed that this treatment was not injurious by superficial examination.

F. Treatment of Cuttings:

The cuttings received various treatments. The stems of some were dipped in growth regulator powders; others were soaked in solutions of growth regulators, sucrose, and vitamin B-1. The cuttings were covered with saran wrap while they were soaking, to prevent leaf desiccation. Treatments are given in Table 2. Most of the leaves were left on the cuttings; only enough were removed to facilitate planting.

G. Propagation Chamber:

Same as described on page 21 with the exception that three propagation flats of a size that would fit in a laboratory autoclave were used. The chamber is shown in figure 3.

H. Rooting Media:

Coarse crystal white sand, Sponge-Rok, and a 50-50 mixture of peat and sand.

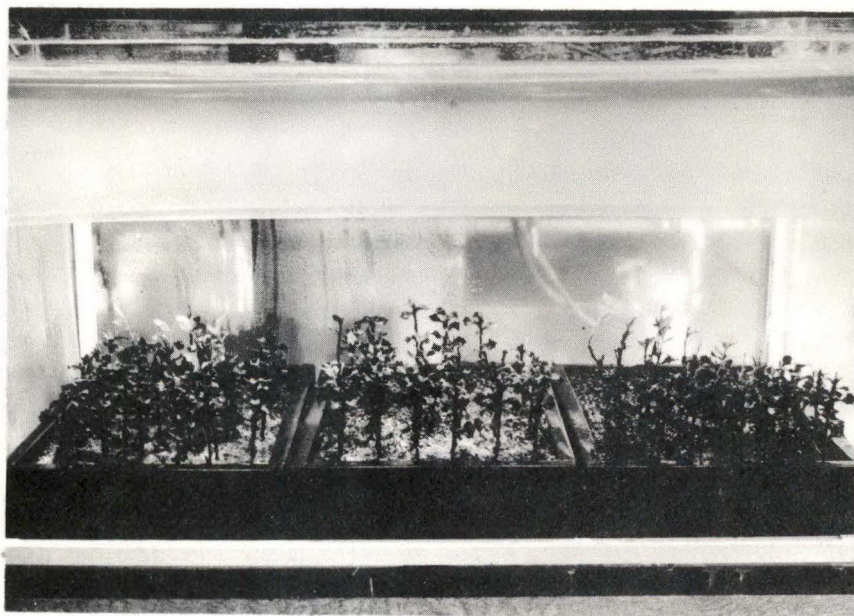
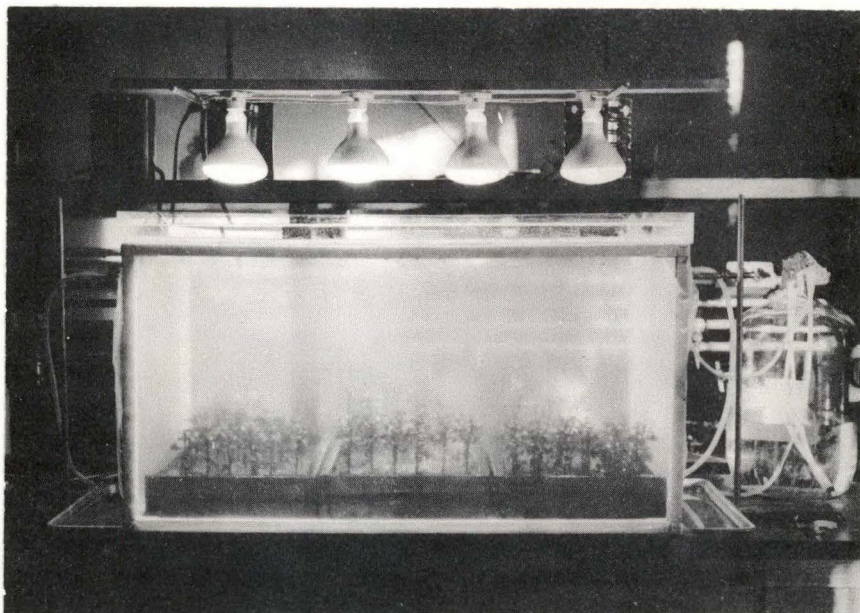


Figure 3.--Laboratory propagation chamber for rooting cuttings.

Table 2.--Rooting results of turbinella oak cuttings under intermittent mist and saturating incandescent light in a laboratory propagation chamber using sanitary procedures (Ept. 1-1-12).

Treatments (All cuttings received a basal stem dip in 0.5% NaOCl for 15 sec.)	Sand				Sponge-Rok				Peat & Sand			
	S	H	C	R	S	H	C	R	S	H	C	R
	Percent				Percent				Percent			
Control	67	83	100	17	50	33	83	0	100	67	83	0
Rootone	67	0	100	0	67	33	100	0	67	67	100	17
Hormodin #2 (0.3% IBA powder)	17	17	17	0	50	67	100	0	83	67	100	0
Hormodin #3 (0.8% IBA powder)	50	0	83	0	100	67	100	0	100	83	100	33
50 ppm NAA + 2% sucrose 36 hr. soak	17	17	33	0	50	17	50	0	67	33	83	0
50 ppm IBA + 2% sucrose 36 hr. soak	100	83	100	0	0	0	17	0	17	0	17	17
2% Sucrose 36 hr. soak + Rootone	33	0	50	0	0	0	33	0	0	0	0	0
50 ppm NAA 36 hr. soak	17	17	67	0	0	17	17	0	0	0	0	0
50 ppm IBA 36 hr. soak	0	0	0	0	0	0	17	0	0	0	0	0
50 ppm IBA + 2% sucrose + 50 ppm thiamin-HCl 36 hr. soak	17	17	17	0	0	50	50	0	0	0	0	0

Abbreviations: S = With New Shoots, H = With Healthy Stems, C = Callused, R = Rooted

IBA, 3-indolebutyric acid; NAA, α -naphthaleneacetic acid

There were 10 cuttings per treatment in each of the three media.

Total number of cuttings: 300.

Cuttings not soaked, September 16, 1958; cuttings soaked for 36 hours, September 18, 1958.

J. Environmental Conditions:

Intermittency of mist was regulated to keep the cuttings just moist, 5-15% operation out of a 5 minute cycle. Distilled water mist, 48 days; nutrient solution mist, 36 days. Average minimum temperature, 70°F.; average maximum temperature, 85°F.; light intensity 1,500-1,700 f.c.; day length, 14 hours.

K. Date of Final Observations: December 9, 1958

L. Duration of Experiment: 84 days

4. Results and Conclusions:

- A. Turbinella oak cuttings were rooted (Fig. 4). The highest percentage of rooting obtained for any treatment was 33%, using Hormodin #3 (0.8% IBA powder) and the peat-sand mixture (Table 2.).
- B. None of the treatments with growth regulator powders or solutions individually or in combination with sucrose or sucrose and thiamin soak treatments, consistently improved rooting.
- C. Most rooting occurred in the 50-50 peat-sand mixture.
- D. In general, the cuttings which were soaked in the various solutions gave poorer results than those treated with growth regulator powders or not treated. This was particularly true of the cuttings in Sponge-Rok and the peat-sand mixture. The soak treatments seemed to predispose the cuttings to stem rot.
- E. Even though careful sanitary procedures were followed stem rot was a serious problem.

- F. The formation of large stem and basal callus balls was common on cuttings which did not seriously decay. Roots were not initiated from the large calluses during the experiment; rather, they developed from small calluses or from areas lacking callus. Many of the cuttings developed new shoots -- but this was not an indication of root formation. A variety of the responses observed are shown in figure 5.
- G. Rooting was not increased in proportion to the increase in number of healthy cuttings. If the cuttings which formed large calluses had rooted the results would have been excellent.



Figure 4.--Rooting of turbinella oak terminal sprout cuttings in a 50-50 peat-sand mixture. From left to right: untreated, Rootone, Hormodin #3 (0.8% IBA powder), 36 hr. soak in 50 ppm IBA + 2% Sucrose solution.



Figure 5.--Various responses of turbinella oak terminal sprout cuttings in sand. Note the large calluses. From left to right: untreated, Rootone, Hormodin #2 (0.3% IBA powder), 36 hr. soak in 50 ppm IBA + 2% sucrose solution, 36 hr. soak in 50 ppm NAA solution.

Propagation of Turbinella Oak 8. Cuttings in Full Sun and Constant Mist
in an Outside Propagation Bed.

Experiment 1-1-10

1. Background:

This experiment was conducted on the assumption that full sunlight and constant mist might provide desirable environmental condition for rooting turbinella oak. In addition to testing these general conditions, an attempt was made to reduce or retard stem rot by means of basal stem-coating treatments thereby increasing the chances of rooting.

2. Objective:

To root turbinella oak under conditions of full sunlight and constant mist.

3. Materials and Methods:

A. Plant Material:

Terminal softwood cuttings were collected from actively growing sprouts in a burned area.

B. Collection Date: August 21, 1958

C. Collection Location: Dewey, Arizona

D. Collection Procedure: Cf. Expt. 1-1-12, Page 23

E. Sanitary Procedures:

The propagation bed was fumigated with methyl bromide at the rate of 8 lbs. per 100 sq. ft. The fumigant was retained by means of a polyethylene sheet. Exposure time 72 hours. Ample time was allowed for the methyl bromide to dissipate before cuttings were planted.

Stems of the cuttings were treated either with 0.5% sodium hypochlorite solution for 15 sec., Captan (fungicide) at 6 Tbs. 50% per gallon, or the following coating materials: paraffin, grafting wax, Treekote, and Flyac^{1/} (1 qt. per gal.).

F. Treatment of Cuttings:

Besides the various treatments to destroy or inhibit pathogens, the cuttings were treated with various root-inducing substances.

G. Propagation Bed:

The outside propagation bed used in Expt. 1-1-2 was altered by installing a series of fog nozzles over the flats. By protecting the mist from wind, by means of a $4\frac{1}{2}$ ft. wind-break around the bed, a uniform mist over the entire bed was obtained. Tap water was used to provide the mist.

H. Rooting Medium: Coarse crystal white sand.

I. Date Planted: August 22, 1958

J. Environmental Conditions:

Constant tap water mist, day and night, (the mist was unintentionally off for a few hours on one day); full sunlight; average minimum night temperature, 67°F.; average maximum day temperature, 89°F.

K. Date of Final Observations: September 19, 1958

L. Duration of Experiment: 28 days

^{1/} Flyac is an emulsifiable polyethylene spreader-sticker; General Chemical Division, Allied Chemical and Dye Corp.

4. Results and Conclusions:

- A. The results of all treatments were partially influenced by the fact that the mist was unintentionally off for a few hours during the day. The cuttings most seriously affected by the mist failure were those whose stems had been treated with coating materials. They were completely dependent on the mist for moisture and dried out beyond the point of recovery. The results with some of the other treatments; however, indicates that the method shows promise and is worthy of further consideration (Table 3).
- B. The highest percentage rooting obtained with any treatment was 33% using Hormodin #1 (0.3% IBA powder); but treatments with growth regulators did not appear to significantly improve rooting.
- C. In spite of the fact that the bed was fumigated and many of the cuttings were treated with sodium hypochlorite solution or Captan, there was considerable stem rot.
- D. During the experiment the top 1-1½ inch of sand became encrusted with salt due to the high salt content of the tap water. It is interesting that in spite of this, some rooting still occurred. The use of distilled or deionized water might give improved rooting results

Table 3.--Rooting results with turbinella oak cuttings under full sunlight and constant mist (Expt. 1-1-10).

Treatment	With Healthy Stems	Callused	Rooted
	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>
Untreated	0	0	17
Captan (fungicide) 6 Tbs. 50% per gal.	0	0	0
Chlorax (0.5% NaOCl for 5 sec.)	50	0	0
Chlorax + Hormodin #1 (0.1% IBA powder)	33	17	0
Chlorax + Hormodin #2 (0.3% IBA powder)	50	17	0
Chlorax + Hormodin #3 (0.8% IBA powder)	0	0	0
Chlorax + Rootone	17	0	0
Captan + Hormodin #1	33	0	17
Captan + Hormodin #2	50	17	0
Captan + Hormodin #3	50	0	17
Captan + Rootone	17	17	0
Hormodin #1	50	0	33
Hormodin #2	50	0	0
Hormodin #3	33	0	17
Rootone	67	0	17

Six cuttings per treatment

1. Background:

Because of the mist failure in Expt. 1-1-10 the cuttings which received basal-coating treatments failed to survive. Accordingly, another set of cuttings was planted in order to evaluate the basal stem-coating treatments for retarding stem rot and promoting rooting.

2. Experiment:

The experimental details and conditions were similar to those of Expt. 1-1-10 with the exception that the mist system functioned continuously without failure. Cuttings were dipped in sodium hypochlorite solution before being treated with the following coating materials: paraffin, grafting wax, Treekote, and Plyac (1 qt. per gal.). Observations were made after 29 days.

3. Results, Discussion, and Conclusions:

None of the treatments satisfactorily reduced stem decay. Best results were obtained with Plyac at 1 qt. per gallon; stem rot appeared to be slightly reduced and rooting slightly increased. More favorable results might be obtained with Plyac in combination with fungicides.

Some interesting observations were made in a preliminary test with Plyac, in the laboratory propagation chamber, to evaluate possible toxic effects of Plyac emulsions of various strengths on turbinella oak cuttings. Plyac at 1 pt. per gallon appeared to have a slight beneficial effect in preventing stem rot and promoting callus formation. Full strength Plyac was injurious -- resulting in severe stem decay. A mixture of Plyac (1 qt. per gal.) and the fungicide Captan (6 Tbs. 50% per gal.) was highly toxic -- killing all of the cuttings so treated -- whereas either component alone was either not injurious or only slightly so. The toxicity of the Plyac-Captan treatment suggests the possibility of increasing the toxicity of herbicides by the addition of Plyac.

Propagation of Turbinella Oak 9. Large Sprouts with Crown Sections or
Underground Stem Pieces Under Jars. (Expt. 1-1-7)

1. Background:

Clumps of sprouts arising from crowns and stumps below the ground following fire, would appear to provide excellent propagation material. A previously described test (Expt. 1-1-1) with a very limited number of large sprouts was unsuccessful but conditions for establishment were poor. The following account describes a propagation test with fairly large sprouts and clumps attached to crown sections or underground stem pieces.

2. Objective:

To propagate turbinella oak from large sprouts attached to crown section or underground stem pieces.

3. Materials and Methods:

A. Plant Material:

Actively growing sprouts, six to nine inches tall, arising beneath the soil were dug from around burned stumps. The sprouts were removed with a piece of the crown or underground stem from which they were growing. Collection of this material was difficult and time consuming.

B. Collection Date: July 15, 1958

C. Collection Location: Dewey, Arizona

D. Handling Precautions:

The sprouts were placed in water as soon as they were collected. They were then sprayed with water and wrapped in wet muslin. They were stored overnight at 80°F in the laboratory and planted the next day. The sprouts were in excellent condition when planted.

E. Treatments:

The sprouts were treated with various chemicals to induce rooting and reduce transplant shock. Cf. Table 4. Powder preparations of Rootone and Hormodin were applied to the crown or underground stem pieces. Solutions to reduce transplant shock were applied to the soil surface following planting.

F. Propagation Procedure:

The sprouts were planted in gallon cans in a sandy loam soil which was obtained from the location where the sprouts were collected. The soil was not sterilized. The planted sprouts were covered with gallon jars. A small beaker of water under each jar maintained a humid atmosphere.

G. Date Planted: July 16, 1958

H. Environmental Conditions:

The sprouts were started in the south window of the air-conditioned laboratory: day temperature, 77°-81°F; night temperature, ca. 72°F.

I. Date of Final Observations: January 7, 1959

J. Duration of Experiment: 176 days

4. Results and Conclusions:

A. Sprouts were successfully established (Table 4).

B. 25% of the untreated sprouts and 25% of the Rootone and Hormodin #1 treated sprouts rooted and survived.

C. 50% of the sprouts which were treated with Hormodin #2, Hormodin #3, or Transplantone rooted. However, it is questionable whether the results of the treatments were significant.

Table 4.--Propagation of turbinella oak from large sprouts attached to crown sections or underground stem pieces (Expt. 1-1-7).

Treatment	Percent Alive			Percent Rooted
	Aug. 20, 1958 35 days	Oct. 20, 1958 96 days	Jan. 7, 1959 175 days	
Untreated	50	25	25	25
Rootone	75	50	25	25
Hormodin #1	50	25	25	25
Hormodin #2	75	50	50	50
Hormodin #3	50	50	50	50
Transplantone	75	50	25	50 ^{1/}
Vitamin B-1	75	0	0	0

Date Planted: July 16, 1958

Hormodin #1, #2, #3: 0.1%, 0.3%, 0.8% 3-indolebutyric acid powder respectively

Transplantone: $\frac{1}{4}$ tsp. per 2 $\frac{1}{2}$ gal.; 100 ml per can.

Contains naphthylacetamide 0.02%, Vitamin B-1, 0.01%.

Vitamin B-1 Liquid: 1 tsp. per gal.; 100 ml per can.

Contains thiamin chloride hydrochloride, 0.0044%.

^{1/} One plant which rooted died.

- D. None of the Vitamin E-1 treated sprouts rooted or survived.
- E. Rooting did not occur from the crown sections but rather from the base of the sprout stems. The sprouts eventually decayed away from the crown sections leaving the rooted sprouts separate.
- F. Rooting occurred from the underground stem pieces.
- G. Although the results show that turbinella oak can be propagated from large sprouts with attached crown sections or underground stem pieces, the method was laborious and time consuming and required several months to establish the plants. After five months the sprouts were not much larger than when they were planted.

PROPAGATION OF TURBINELLA OAK FROM ACORNS

Introductory Statement

With most plants the simplest method of propagation is from seed. And this is especially true of turbinella oak. Assuming that a yearly supply of acorns is assured, which it is not, there would be no problem of raising seedlings for laboratory and greenhouse studies. The following account deals with the collection of turbinella oak acorns, their germination, storage, seedling growth, and growth problems learned through personal experience and experimentation. The work began as soon as the acorn crop matured in August 1958 and was conducted while the plants were being raised for herbicide studies.

Collection of Acorns

The majority of turbinella oak bushes in the chaparral belt of Arizona are relatively low, ranging from three to six feet in height, and in dense stands. Collection of acorns from such bushes usually necessitates hand picking. Frequently, however, large bushes ranging in size up to small trees are found in isolated spots and along washes or river beds where water is more plentiful. Such trees are sometimes found with a heavy crop of acorns, and in these cases the acorns can be collected easily by knocking them off the branches onto a canvas beneath the tree.

Turbinella oak acorns in Arizona ripen from August through September depending on the location, and drop when they become ripe. They should be collected while they are still on the tree. Fallen acorns may have dried out beyond the point of germinability. Such acorns can usually be identified by their light brown color in contrast to the dark brown color of fresh ripe acorns.

One of the environmental factors limiting acorn production is moisture. The set of acorns may be heavy, yet if rain does not occur to provide for their continued development, the acorns will abort. This is what happened in 1958. Losses due to weevils were heavy also. After extensive searching only a few trees were found which had a good supply of acorns.

Germination (Expts. 2-1-1 and 2-1-10)

Turbinella oak acorns have no dormancy and will germinate soon after falling. The germination of freshly harvested ripe acorns is excellent -- ranging from 81-94%. Green acorns may also show excellent germination; in one test they gave 92% germination and produced normal seedlings. Acorns infested with the eggs of larvae of weevils will also germinate provided the embryo is not injured. Germination proceeds most rapidly at about 80°F (Table 5). A constant temperature of 90°F is inhibitory.

Table 5.--The influence of temperature on germination of turbinella oak acorns (observations after 15 days) Expt. 2-1-10.

Temperature (°F)	Germination	Average Radicle Length (cm)	Remarks
60	75	3.5	
74-78	60	3.5	
80	65	6.2	Many shoots
90	50	1.8	Radicles dead or dying

Storage (Expt. 2-1-1)

In order to start turbinella oak seedlings throughout the year, it is necessary to be able to store acorns in a viable condition. Otherwise large numbers of plants would have to be established at the same time, which is not always convenient from the standpoint of space utilization. Since information was not available on the storage of turbinella oak acorns, the recommendation of moist cold storage for the closely related Quercus dumosa of California was adopted. This method was suggested by N. T. Mirov, U. S. Forest Service, Berkeley, California, and involved stratifying the acorns in moist peat and storing them at 35°F. There was a shortage of 35°F storage space at the time but ample 40° and 50°F space was available. Accordingly, a storage experiment was established to determine the adequacy of existing facilities. Besides testing moist cold storage with and without peat, other conditions such as dry storage in sealed jars at room temperature and dry cold storage in open containers were tested. The results of this test are given in Table 6.

Table 6.--Storage of turbinella oak acorns.

Storage Condition	Temperature (°F)	No. of Days Before Acorns Started to Germinate	Germinative Capacity
Surface dry in sealed jar	77-80	1	Good (84%)
Moist in sealed jar	50	14	Good
	40	34	Good
	35	54	Good (79%)
Moist peat in sealed jar	50	14	Good
	40	34	Good
	35	54	Good
Surface dry in open container	36	-	Very poor after 55 days

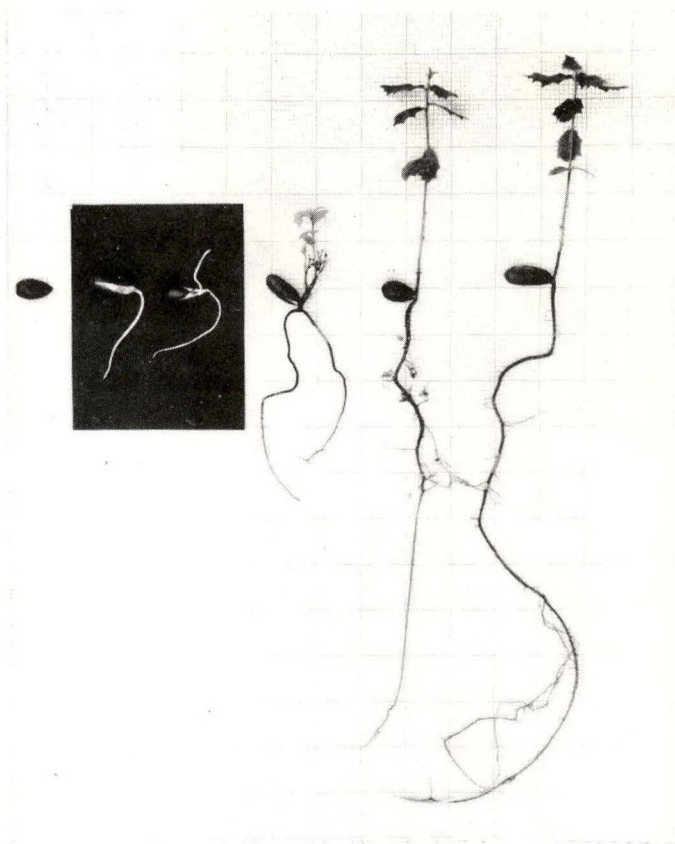


Figure 6.--Turbinella oak seedling history. From left to right: acorns, 12 day old germinating acorns, an acorn with multiple shoots, and 67 day old seedlings.

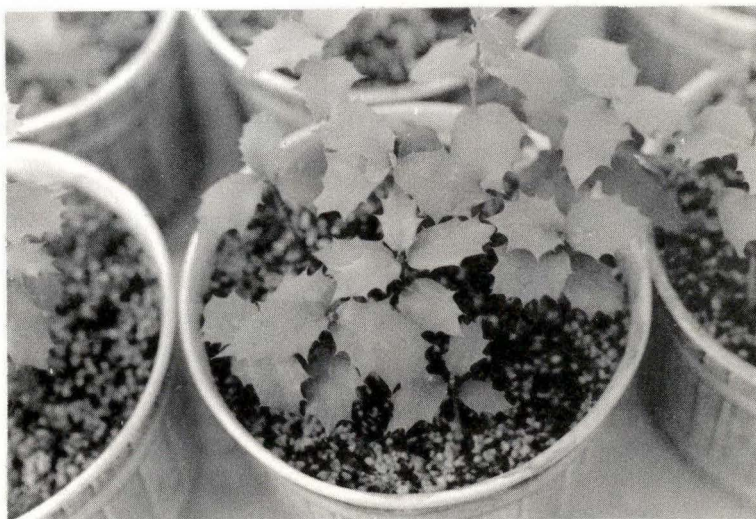


Figure 7.--Fifty-three day old turbinella oak seedlings.

The problem of storage was that of preventing germination while maintaining viability. Surface dry acorns in sealed jars at room temperature germinated after one day. By storing the acorns moist, either with or without peat, they started to germinate after 14 days at 50°F, 34 days at 40°F, and 54 days at 35°F, all having good germinability. Acorns stored dry in open containers at 46°F for 55 days germinated very poorly. In order to retard the germination of some of the acorns which had begun to germinate they were stored at 30°-32°F. After six months of storage under these conditions, only 11 percent continued to germinate.

Other methods will have to be used for storing turbinella oak acorns longer than two months. Conditions which might prove satisfactory include dry cold storage in sealed jars at 30°-35°F and moist cold storage at 30°-32°F.

Seedling Growth

Shoots from planted acorns emerge from the soil in four to seven days, depending on conditions. And in 10 days they are $\frac{1}{2}$ - 2 inches tall. After the first few pairs of leaves expand, however, growth slows down markedly. The history of turbinella oak seedling development is shown in figure 6 and a stand of seedlings 53 days old is shown in figure 7.

Turbinella oak seedlings grow slowly. This is indicated by the data in Table 7. These data are for several groups of plants which were grown under a variety of conditions before greenhouse facilities were available. Because the seedlings have grown so slowly an experiment is being conducted to determine optimum light and temperature conditions for growth.

Some of the problems encountered in raising turbinella oak seedlings include salinity injury, post-emergence damp-off, and powdery mildew disease.

Table 7.--Growth of turbinella oak seedlings under various environmental conditions.

Growth Medium	Seedlings	Dates (1958)	Ave. Temp. (°F)		Light Intensity (f.c.)	No. of Days Growth	Average Seedling Height (cm)	Growth Rate (cm./day)
			Min.	Max.				
Vermiculite	330	Oct. 3-Dec. 5	70	83	600	63	9.2	0.15
Sandy Loam Soil	56	Aug. 23-Oct. 16	73	97	2,000	54	6.6	0.12
Sandy Loam Soil	56	Oct. 16-Dec. 5	56	74	500	50	0.2	0.004
Sandy Loam Soil	78	Aug. 23-Oct. 16	72	78	600	54	7.4	0.14
Sandy Loam Soil	78	Oct. 16-Dec. 5	56	74	500	50	0.8	0.016
Sandy Loam Soil	120	Sept. 8-Oct. 24	72	80	600	45	7.4	0.16
Sandy Loam Soil	120	Oct. 24-Dec. 5	54	72	500	42	0.2	0.004

Salinity.--Seedlings are sensitive to salinity injury (Fig. 8). This was learned when a fairly large planting of acorns was watered frequently with light applications of the local water. When the salinity of the soil was reduced by leaching it with distilled water many of the seedlings recovered. Since then the problem of salinity has been avoided by using distilled water.

Post-emergence damp-off.--Young seedling shoots in a medium kept excessive moist are susceptible to damp-off. This is true whether the medium is sub-irrigated or excessively sprinkled. Under such conditions it is common for five or six shoots to develop and die in succession. However, if the medium is allowed to dry new shoots will frequently develop and survive.

Powdery mildew.--Turbinella oak seedlings and sprouts are susceptible to powdery mildew. The disease occurs commonly but can be controlled with sulfur sprays.

COMPARISON OF PROPAGATION METHOD RESULTS

A comparison of the "end result" of various propagation methods is shown in figure 9. Although the sprout initially provides a relatively large plant it becomes established very slowly and is soon equalled in height by a seedling. The same is true of cuttings. Because of the difficulties involved in rooting sprouts and cuttings, the methods will be used only if acorns are not available. And in the event of an acorn shortage, the knowledge gained concerning the rooting of sprouts and cuttings will be of considerable value.



Figure 8.--Salinity injury to turbinella oak seedlings.



Figure 9.--Turbinella oak propagation results by several methods. All plants are rooted. From left to right: large multiple sprout with underground stem or crown piece, 183 days old; terminal sprout cutting, 142 days old; seedling, 153 days old.

LABORATORY STUDY

Introductory Statement

As soon as a suitable group of seedlings became available in late December an experiment was established with a group of granular and pelleted herbicides as soil applications.

The Influence of Soil Applications of Several Granular and Pelleted Herbicides on Turbinella Oak Seedlings in a Greenhouse Test. (Expt. 4-1-1)

1. Background:

Because of the ability of turbinella oak to sprout from crown wood below ground level and from underground stems following injury to the tops, soil applications of herbicides may offer peculiar advantages for chemical control of the shrub. For this reason a group of herbicides were tested as soil applications.

2. Objective:

To evaluate a group of granular and pelleted herbicides, applied as soil applications, for their ability to control turbinella oak seedlings.

3. Materials and Methods:A. Plant Material:

Approximately four month old seedlings grown in soil contained in gallon cans.

B. Soil:

Sandy loam soil collected in an area indigenous to turbinella oak, Dewey, Arizona.

C. Location: Greenhouse, Tempe, Arizona

D. Treatments:

All treatments were applied at the rates of 2,4,8 and 16 lbs.
active ingredient per acre.

Chemical Treatment Number	Designation	Chemical	Percent Active Ingred.	Source
1.	Monuron pellets	3-(p-chlorophenyl)-1,1-dimethylurea	25	duPont
2.	Fenuron pellets	3-phenyl-1,1-dimethylurea	25	duPont
3.	Urox granules	3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate	22	Gen. Chem
4.	TBA granules	trichlorobenzoic acid, 23.75%; other polychlorobenzoic acids, 1.25%	25	duPont
5.	Simazine 8-G granules	2-chloro-4,6-bis(ethylamino)-s- triazine	8.5	Geigy
6.	2,4-D ester granules	2,4-dichlorophenoxyacetic acid, butoxyethanol ester	10	Amchem
7.	2,4,5-T ester granules	2,4,5-trichlorophenoxyacetic acid, butoxyethanol ester	10	Amchem
8.	Silvex ester granules	2,4,5-trichlorophenoxypropionic acid, butoxyethanol ester	10	Amchem
9.	Control			

4. Results:

Results of the experiment are not yet complete and it is too early to predict the outcome. However, after four weeks none of the stands have been killed. At the present time the chemicals which look most promising are: Fenuron; TBA; 2,4-D; 2,4,5-T; and silvex.

FIELD STUDY

Plans for a cooperative field experiment with Dr. D. T. Lillie entitled "The Effectiveness of Pellet and Granular Applications of Several Herbicides, as Influenced by Leaching, for the Control of Turbinella Oak" were formalized and approved. Cf. CR fl-17 Research Work Plan No. 1. The experiment will be initiated early in 1959.

APPENDIX

1. Attendance at Meetings:

- A. AAAS Meeting, Pacific Coast Section, Logan Utah. June 17-20, 1958.
- B. Research Advisory Council Meetings, Rocky Mountain Forest and Range Experiment Station, April 9 and September 26, 1958.

2. Lectures:

Delivered 2 lectures to the weed control class at Arizona State University on the subject of woody-plant control, May 6, and 15, 1958.

ACKNOWLEDGEMENTS

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